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COST OF DISSOLVED AIR FLOTATION THICKENING OF WASTE ACTIVATED SLUDGE AT MUNICIPAL SEWAGE TREATMENT PLANTS

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by

Walter F. McMichael

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NATIONAL ENVIRONMENTAL RESEARCH CENTER
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
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FOREWORD

Man and his environment must be protected from the adverse effects of pesticides, radiation, noise and other forms of pollution, and the unwise management of solids waste. Efforts to protect the environment require a focus that recognizes the interplay between the components of our physical environment--air, water, and land. The National Environmental Research Centers provide this multidisciplinary focus through programs engaged in

- studies on the effects of environmental contaminants on man and the biosphere, and
- a search for ways to prevent contamination and to recycle valuable resources.

A. W. Breidenbach, Ph.D.
Director
National Environmental
Research Center, Cincinnati

ABSTRACT

Estimates are presented of the capital and operating costs and the operation and maintenance labor man-hours that are associated with flotation thickening.

COST OF DISSOLVED AIR FLOTATION THICKENING OF WASTE ACTIVATED SLUDGE AT MUNICIPAL SEWAGE TREATMENT PLANTS

In the United States, flotation thickening equipment is supplied principally by two manufacturers: Komline-Sanderson Engineering Corporation and Rex-Chainbelt, Incorporated. Much of the information in this report was obtained from representatives of these companies. Other information, particularly that having to do with manpower requirements for operating and maintaining flotation thickening equipment, was obtained from telephone conversations with operating personnel at municipal sewage treatment plants. Both manufacturers indicated that the process of flotation thickening is receiving increasing acceptance as a means of thickening waste activated sludge, which is frequently difficult to thicken in conventional settlers.

Costs for this process are presented here in two ways. First, capital cost and operating and maintenance cost are shown as functions of the design capacity of the sewage treatment plant. (Figure 1 and Table I). This method is appropriate when flotation thickening is considered as a separate process apart from the remainder of the treatment plant. Second, construction cost, man-hour requirements, and materials and supply costs are presented as functions of appropriate process sizing parameters (Figures 2, 3, and 4). This makes the costs, for this process, compatible with the costs of other unit processes given in other reports (1, 2).

Flotation aids (usually cationic polymers) may be used to increase the loading rates of flotation thickeners. Conservative loading rates may be assumed to be about 10 pounds of dry solids per day per square foot of thickener surface area without polymer addition and about 30 pounds per day per square foot with polymer addition. Higher rates may be achieved in some cases. The economic factors that influence the choice of whether or not to use polymers are discussed later.

Like vacuum filtration and incineration, flotation thickening is a process that may be operated only part time. This practice seems to be more prevalent at small plants than at large installations. It is necessary, of course, to decide on an operating schedule before the size of equipment required, for a given installation, may be determined. The operating schedule of flotation thickeners, assumed for this cost estimate, is:

Up to 2 mgd	40	hours	per	week
2 to 5.....	80	"	"	"
5 to 20.....100		"	"	"
over 20.....168		"	"	"

The operating schedule must also be taken into account when the decision is made as to whether the required thickener area is to be provided by one large thickener or by several small ones. Where the equipment is operated continuously, two or more units are commonly used to provide flexibility and to permit shut-down for maintenance, even though single units of sufficient capacity may be available. This practice of having two or more units has been followed in this cost estimate; at least two flotation thickeners have been assumed for plants of over 20 mgd capacity. However, no idle thickeners are included in estimating costs for those plants that operate 24 hours per day.

After loading rates, operating schedules, and excess capacity factors have been established, thickener sizes and, therefore, capital costs may be determined. Prices of flotation thickening equipment were obtained from the two manufacturers. A manufacturer and a general contractor with experience in this work supplied estimates of installation labor costs.

The size of flotation thickeners is expressed in square feet of surface area. Manufacturers offer product lines that range in size from 50 to about 200 square feet. Typical standard sizes

are 50, 100, 150, 200, 250, 300, 400, 450, 500, 600 and 800 square feet. Larger sizes are built to meet individual customer requirements. From 50 to about 450 square feet, flotation thickeners are offered as factory-assembled units with steel tanks. Above that size, the mechanical components are supplied for installation in concrete basins. In this report, the cost of concrete basins has been included in the equipment cost of thickeners larger than 450 square feet.

Where freezing weather may be expected, flotation thickeners would normally be enclosed in buildings. Therefore, estimated costs of such buildings have also been included in the construction costs. Process design assumptions on which this estimate is based are:

Type of Sludge	Waste Activated
Quantity of Sludge	980 lb. dry solids per mg
Loading Rate with Polymer	30 lb. per sq. ft. per day
Loading Rate without Polymer	10 lb. per sq. ft. per day
Polymer Dose (where applicable)	10 lb. per ton of dry solids
Polymer Price	$0.45 per pound
Excess Capacity Factor	None except that provided by operating schedules of less than 168 hours per week and the use of the nearest larger standard size thickener

Figure 1 and Table 1 present the capital costs, operating and maintenance costs, and debt service, versus the design capacity of the sewage treatment plant, for dissolved air flotation thickening of waste activated sludge. The term "capital cost" includes the estimated construction cost plus allowances of 20 percent of construction cost for consulting engineering services, legal, fiscal and administrative costs and 14 percent of construction cost for a proportionate share of the treatment-plant yard work.

Operation and maintenance costs are made up principally of operating and maintenance labor, electric power, and chemical

costs. Chemical (polymer) cost is, of course, the product of the unit price of the polymer used and the dose. Polymer prices may range from as little as $0.20 to almost $2.00 per pound. For this process, however, some of the less expensive polymers apparently will perform acceptably. In these estimates, the average polymer price was assumed to be $0.45 per pound and the dose rate was 10 pounds per ton of dry sludge solids. Operating labor applies to the flotation thickeners and associated equipment. Maintenance labor applies to the process equipment and the enclosing structure. Labor costs were based on an hourly rate of $6.00 per hour. An amount equal to 25 percent of the direct labor was added to cover indirect and administrative labor costs.

Costs of flotation thickening, both with and without polymer addition, are plotted on Figure 1. This plot illustrates that, within the limits of accuracy of this conceptual estimate and for the conditions stated, there is practically no difference in total treatment costs between a process that includes polymer addition and one that does not, except at the smallest sizes of plants.

Figure 2 presents construction costs of dissolved air flotation thickening as a function of thickener surface area. The term "construction costs," as used here, includes all the normal elements of construction costs usually encountered by a contractor. Not included are consulting engineering, legal, fiscal, or administrative costs nor any construction work outside the limits of the flotation thickening facility. Estimated costs (Figure 2) apply whether polymer addition is employed or not since the cost of polymer handling equipment was considered to be a negligible fraction of the total cost.

In Figures 3 and 4, operating and maintenance man-hour requirements and material and supply costs are depicted as functions of the weight of dry sludge solids thickened. Figure 3 pertains

to those installations where polymer addition is not employed, whereas Figure 4 applies to those where it is. The term "materials and supplies" includes polymer cost (where applicable), electric power, and maintenance materials and parts. The same assumptions relating to operating schedules and design criteria were made for Figures 3 and 4 as were made for Figure 1.

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1. Black and Veatch Consulting Engineers. "Estimating Costs and Manpower Requirements for Conventional Wastewater Treatment Facilities." Water Pollution Control Research Series Publication 17. Office of Research and Monitoring, U.S. Environmental Protection Agency.

2. Eilers, R. G. and Smith, R.. "Executive Digital Computer Program for Preliminary Design of Wastewater Treatment Systems." Water Pollution Control Research Series WP-20-14, Office of Research and Monitoring, U.S. Environmental Protection Agency.

Table 1

COSTS OF DISSOLVED AIR FLOTATION THICKENING
OF WASTE ACTIVATED SLUDGE (See Figure 1)

	Design Capacity					
	1		10		100	
	without polymer	with polymer	without polymer	with polymer	without polymer	with polymer
Capital cost, $1000	145	86	280	160	1400	600
Amortization, ¢/1000 gal (6%, 25 yr)	3.1	1.8	0.60	0.34	0.30	0.13
Operating and maintenance cost, ¢/1000 gal	0.8	1.1	0.26	0.55	0.17	0.36
Total cost, ¢/1000 gal	3.9	2.9	0.86	0.89	0.47	0.49

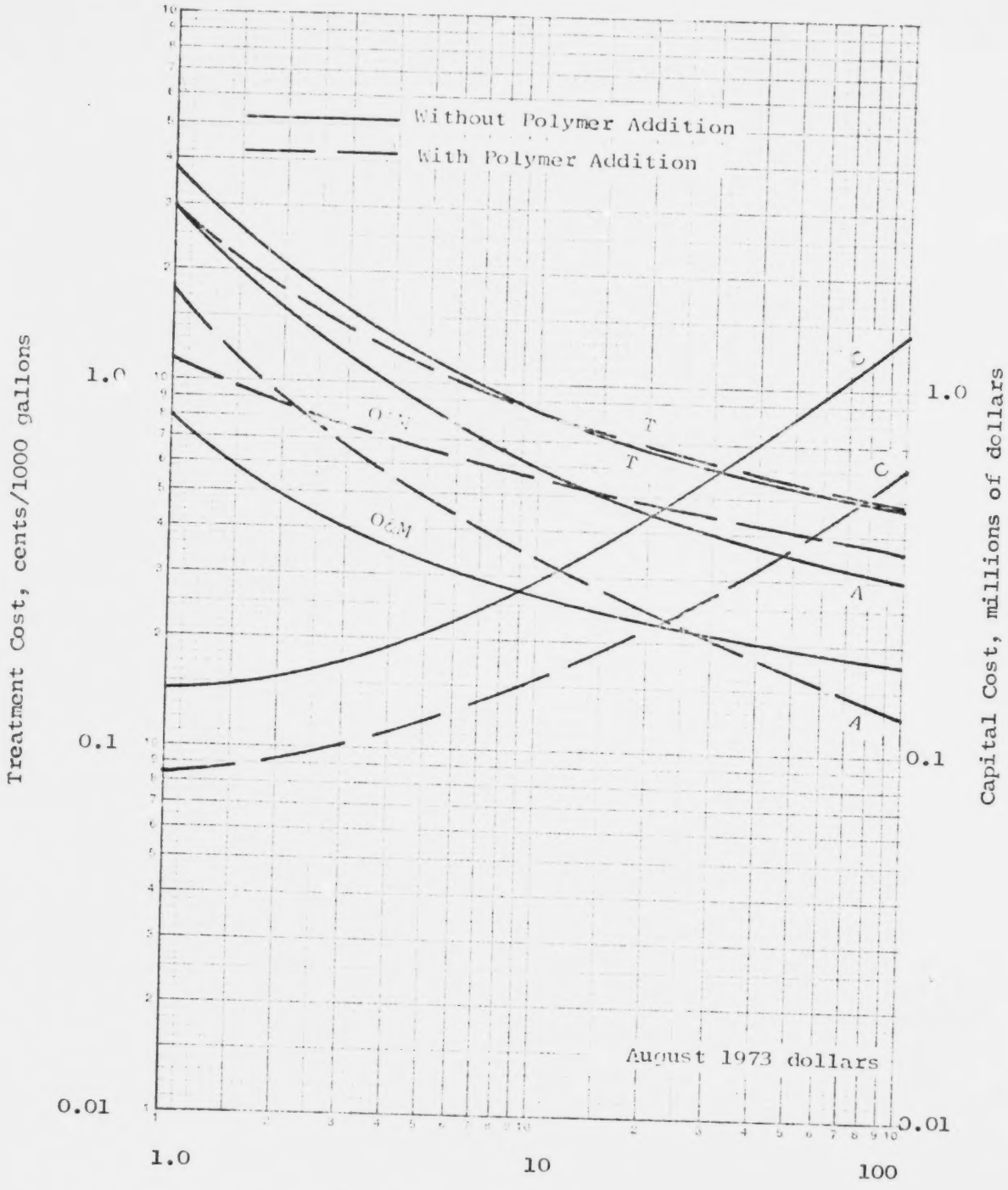

Figure 1

Capital cost, operation and maintenance cost, and debt service versus design capacity of treatment plant.

C = capital cost, in millions of dollars; A = amortization (6% - 25 yr), in cents per 1000 gallons; O + M = operating and maintenance cost, cents per 1000 gallons; and T = total treatment cost in cents per 1000 gallon.

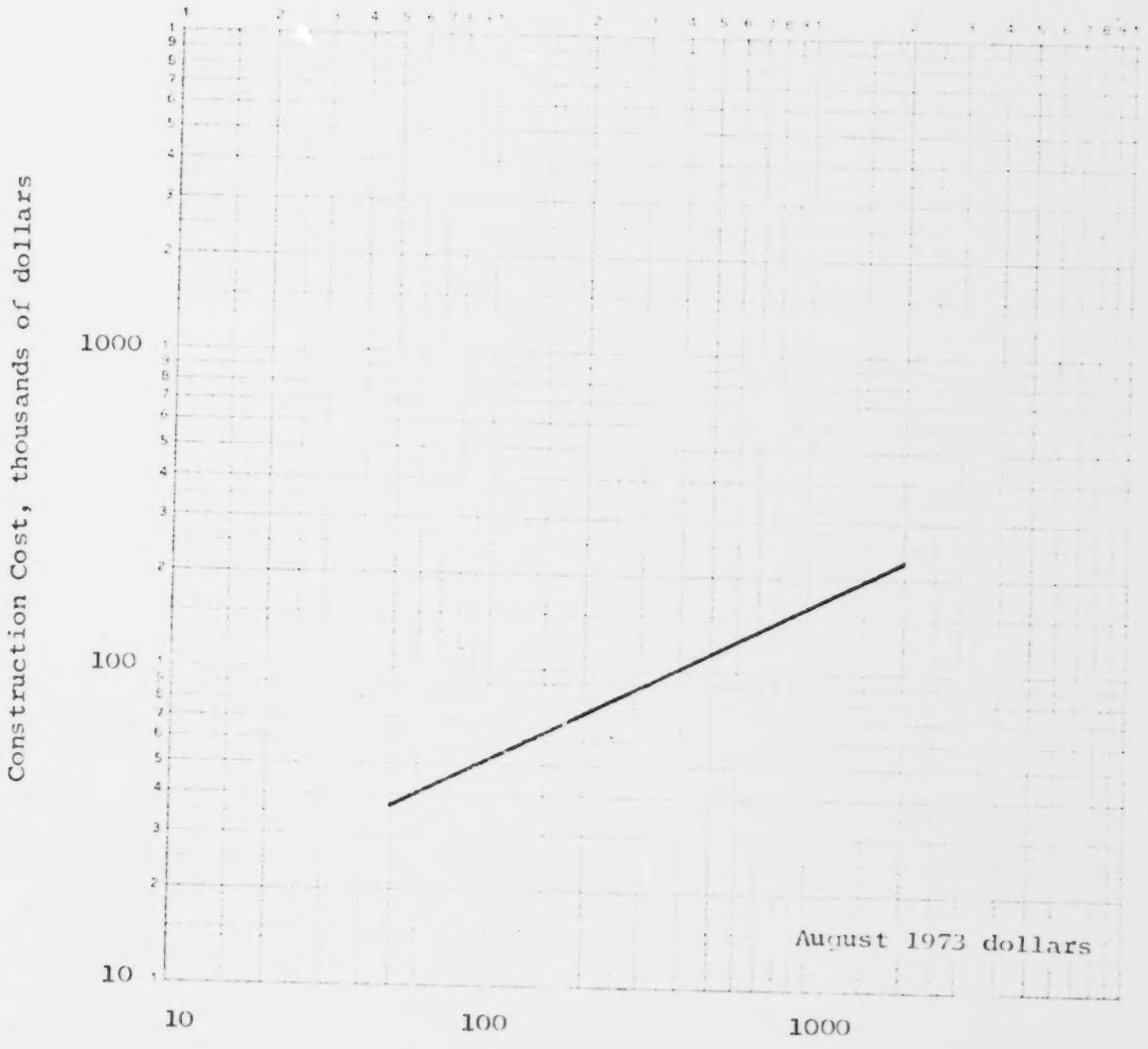

Figure 2

Construction cost versus thickener area.

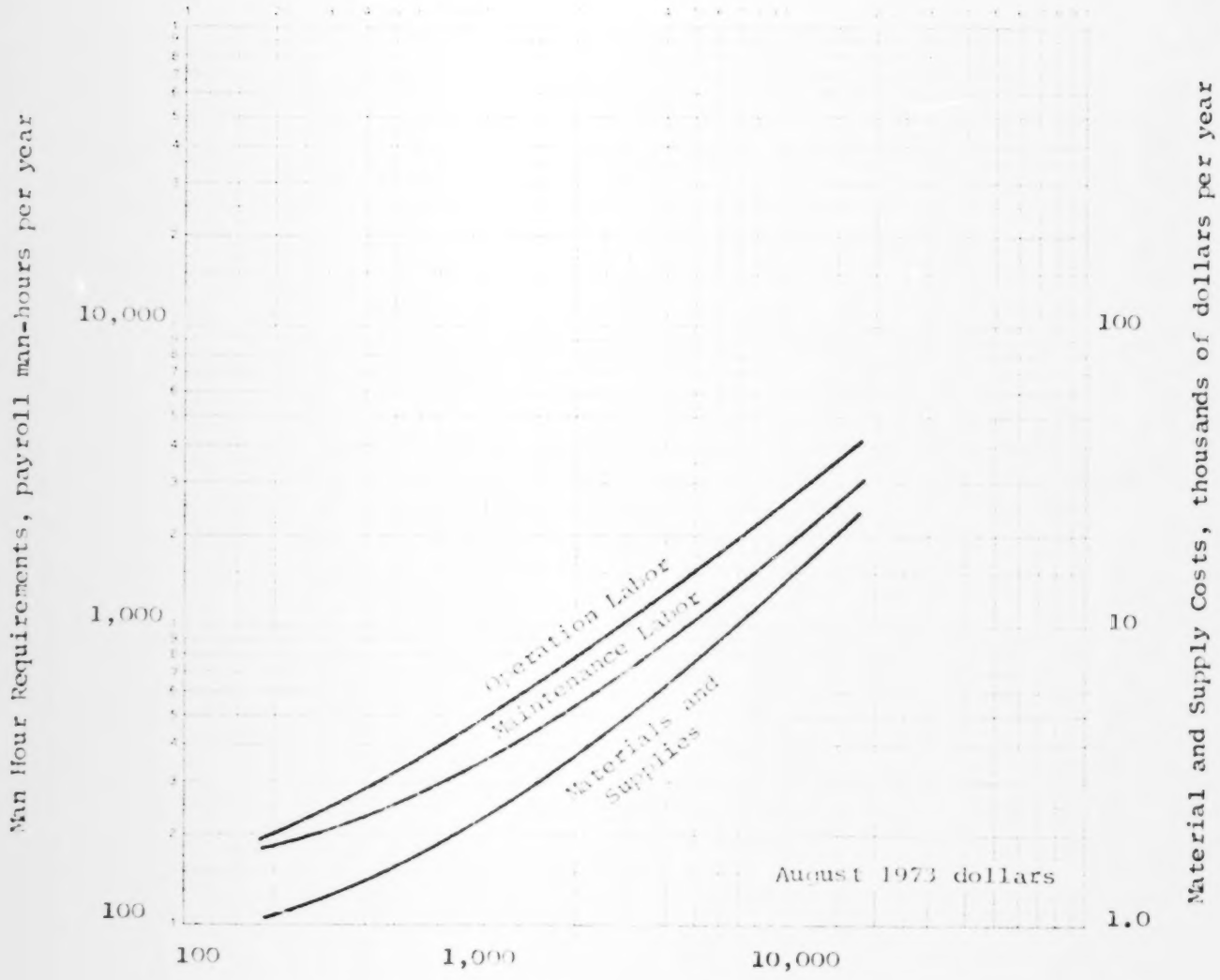

Figure 3

Man-hour requirements and material and supply cost versus quantity of sludge thickened when no polymer added.

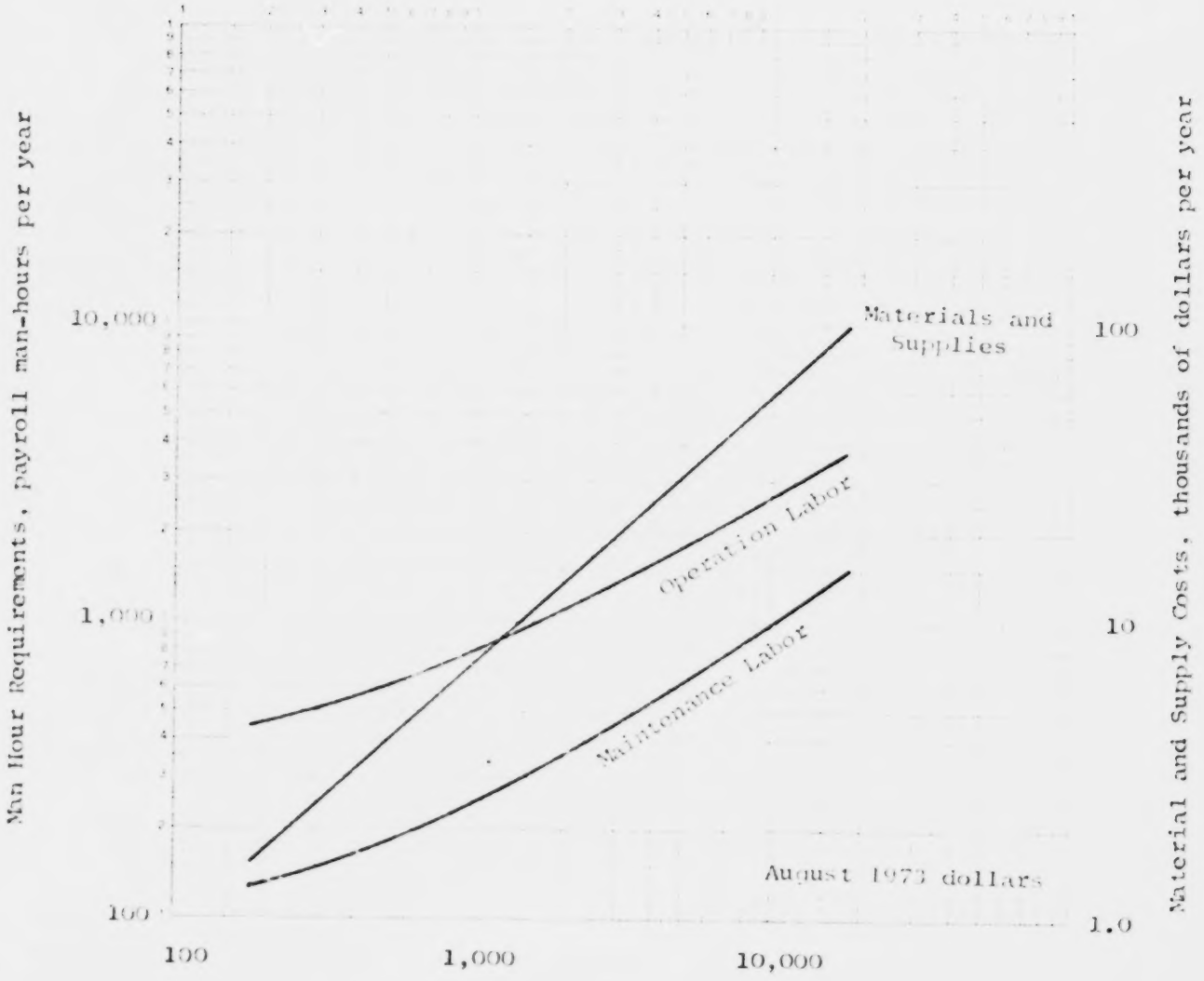

Figure 4

Man-hour requirements and material and supply costs versus quantity of sludge thickened when polymers added.